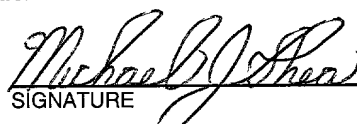


FORM PTO-1390 (REV 11-2000)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 1275-45
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5) 09/914009 Unknown
INTERNATIONAL APPLICATION NO. PCT/JP00/01162	INTERNATIONAL FILING DATE 29 February 2000	PRIORITY DATE CLAIMED 1 March 1999
TITLE OF INVENTION SPREAD-SPECTRUM COMMUNICATION DEVICE		
APPLICANT(S) FOR DO/EO/US FUKUMASA		
<p>Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:</p> <ol style="list-style-type: none"> <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. <input checked="" type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below. <input checked="" type="checkbox"/> The U.S. has been elected by the expiration of 19 months from the priority date (Article 31). A copy of the International Application as filed (35 U.S.C. 371(c)(2)). <ol style="list-style-type: none"> <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau). <input checked="" type="checkbox"/> has been communicated by the International Bureau. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). <input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). <ol style="list-style-type: none"> <input checked="" type="checkbox"/> is attached hereto. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4). <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) <ol style="list-style-type: none"> <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). <input type="checkbox"/> have been communicated by the International Bureau. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. <input type="checkbox"/> have not been made and will not be made. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). <input checked="" type="checkbox"/> A English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). <p>Items 11 To 20 below concern document(s) or information included:</p> <ol style="list-style-type: none"> <input type="checkbox"/> An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. <input checked="" type="checkbox"/> A FIRST preliminary amendment. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. <input type="checkbox"/> A substitute specification. <input type="checkbox"/> A change of power of attorney and/or address letter. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4). <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4). <input checked="" type="checkbox"/> Other items or information. PTO-1449/ International Search Report/ Front page of the PCT Publication 		

U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5) 09/914009		INTERNATIONAL APPLICATION NO PCT/JP00/01162		ATTORNEY'S DOCKET NUMBER 1275-45	
21. <input checked="" type="checkbox"/> The following fees are submitted:				CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5)): -- Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO\$1000.00 -- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO.....\$860.00 -- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO\$710.00 -- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4).....\$690.00 -- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4).....\$100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				\$	860.00
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).				\$	0.00
CLAIMS		NUMBER FILED	NUMBER EXTRA	RATE	
Total Claims		8	-20 =	0	X \$18.00
Independent Claims		2	-3 =	0	X \$80.00
MULTIPLE DEPENDENT CLAIMS(S) (if applicable)				\$270.00	\$ 0.00
TOTAL OF ABOVE CALCULATIONS =				\$	860.00
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.					0.00
SUBTOTAL =				\$	860.00
Processing fee of \$130.00, for furnishing the English Translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)).					0.00
TOTAL NATIONAL FEE =				\$	860.00
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property				+	\$ 40.00
Fee for Petition to Revive Unintentionally Abandoned Application (\$1240.00 - Small Entity = \$620.00)					\$ 0.00
TOTAL FEES ENCLOSED =				\$	900.00
				Amount to be:	
				refunded	\$
				Charged	\$
a. <input checked="" type="checkbox"/> A check in the amount of \$900.00 to cover the above fees is enclosed. b. <input type="checkbox"/> Please charge my Deposit Account No. 14-1140 in the amount of \$_____ to cover the above fees. A duplicate copy of this form is enclosed. c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 14-1140. A duplicate copy of this form is enclosed. d. <input checked="" type="checkbox"/> The entire content of the foreign application(s), referred to in this application is/are hereby incorporated by reference in this application.					
NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO: NIXON & VANDERHYTE P.C. 1100 North Glebe Road, 8 th Floor Arlington, Virginia 22201-4714 Telephone: (703) 816-4000					
				 SIGNATURE	
				Michael J. Shea NAME	
				34,725 REGISTRATION NUMBER	
				August 22, 2001 Date	

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22 AUG 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

FUKUMASA

Atty. Ref.: 1275-45

Serial No. Unknown

Group:

Filed: August 22, 2001

Examiner:

For: SPREAD-SPECTRUM COMMUNICATION DEVICE

* * * * *

August 22, 2001

Assistant Commissioner for Patents
Washington, DC 20231

Sir:

PRELIMINARY AMENDMENT

In order to place the above-identified application in better condition for examination,
please amend the application as follows:

IN THE CLAIMS

Please substitute the following amended claims for corresponding claims previously
presented. A copy of the amended claims showing current revisions is attached.

4. (Amended) The spectrum spread communication system according to Claim 1, further
comprising:

a mapping circuit disposed prior to the transmitter for mapping the multiplexed
transmission signals to points on the I-Q plane.

7. (Amended) The spectrum spread communication system according to Claim 5, further
comprising:


a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

REMARKS

The above amendments are made to place the claims in a more traditional format. Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "**Version With Markings To Show Changes Made.**"

Respectfully submitted,

NIXON & VANDERHYE P.C.

By: 
Michael J. Shea
Reg. No. 34,725

MJS:ms
1100 North Glebe Road, 8th Floor
Arlington, VA 22201-4714
Telephone: (703) 816-4000
Facsimile: (703) 816-4100

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS

4. (Amended) The spectrum spread communication system according to Claim 1 ~~or~~ 2, further comprising:

a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

7. (Amended) The spectrum spread communication system according to Claim 5 ~~or~~ 6, further comprising:

a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

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DESCRIPTION

SPREAD SPECTRUM COMMUNICATION SYSTEM

5 Technical Field

The present invention relates to a spread spectrum communication system based on the direct sequence spreading scheme, for a portable phone and mobile communication system, for example.

10

Background Art

In recent years, research and development as to mobile communication systems using the spread spectrum technology based on the direct sequence spreading scheme have been extensively made. Such communication systems include a system used worldwide and known as cdmaOne, and the W-CDMA system and the Wideband cdmaOne(cdma2000) system which both are aiming at the standard for IMT-2000 (see Tero Ojanperä and Ramjee Prasad, "An Overview of Air Interface Multiple Access for IMT-2000/UMTS", IEEE Communications Magazine, September 1998. etc.). Among these, particularly for the W-CDMA, use of roll-off filters having small roll-off ratios is demanded in order to reduce the required bandwidth as small as possible relative to the chip rate. As the spread spectrum communication system for this scheme, a method combined with

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QPSK(quadri-phase shift keying) has been proposed.

Fig.1 shows a block diagram of a transmitter of this spread spectrum communication system of the QPSK scheme. The transmitter of this spread spectrum communication system is comprised of a complex spreading portion 701 for performing complex spreading modulation of data D_i and D_q which are the I-phase component(in-phase component) and the Q-phase component(quadrature-phase component) of the transmission signal, roll-off filters 708 and 709, a carrier modulator 716, a power amplifier 715 and an antenna 717.

Complex spreading portion 701 includes multipliers 702 to 705 for multiplying the I-phase and Q-phase data by complex number sequences W_0 and W_1 and adders 706 and 707 each performing addition of the I-phase and Q-phase data modulated by W_0 and W_1 .

Carrier modulator 716 includes a sinusoidal wave generating circuit 710, a phase-rotation circuit 713 for rotating the phase of the sinusoidal wave by $\pi/2$, a multiplier 711 for modulating the data having passed through roll-off filter 708 by the sinusoidal wave and a multiplier 712 for modulating the data having passed through roll-off filter 709 by the sinusoidal wave rotated in phase by $\pi/2$, and an adder 714 for performing addition of these pieces of modulated data.

However, since the signal waveforms having passed through

the roll-off filters present large dynamic ranges, a spread spectrum communication system of this type may be demanded high linearity for a power amplifier and other circuits.

To deal with the problem of this kind, Japanese Patent Publication Hei 7 No.312391 discloses a spread spectrum transmitter/receiver in which spectrum spreading and a $\pi/4$ shift QPSK are applied in combination. In this $\pi/4$ shift QPSK, since the positions of the signal points of sequential symbols differ in phase by $\pi/4$ from each other, the envelop will not cut the point '0' when the signal transits from one signal point to another, so that the variations of the envelop is known to be small. This effect can be similarly obtained when it is applied to a spread spectrum scheme.

On the other hand, as found in 'Global CDMA II for IMT-2000 RTT System Description' TTA, Korea (June 17, 1998), a special spreading scheme based on the combination of pseudo-random sequence and Walsh sequence has been also proposed. Now, this scheme is called OCQPSK(orthogonal complex QPSK) and the block diagram is shown in Fig.2.

The transmitter for the spread spectrum communication system based on this OCQPSK scheme is comprised of multipliers 802 and 803 for modulating the I-phase and Q-phase data D_i and D_q by Walsh sequences W_0 and W_2 , respectively, a complex spreading portion 801 for performing complex spreading modulation, multipliers 810 and 811 for scrambling the data

with pseudo-random sequences $PN^{(k)}$, roll-off filters 812 and 813, a carrier modulator 820, a power amplifier 819 and an antenna 821.

Complex spreading portion 801 includes multipliers 804 to 807 for multiplying the I-phase and Q-phase data modulated by W_0 and W_2 by complex number sequences W_0 and W_1 , and adders 808 and 809 each performing addition of the I-phase and Q-phase data modulated by W_0 and W_1 .

Carrier modulator 820 includes a sinusoidal wave generating circuit 814, a phase-rotation circuit 817 for rotating the phase of the sinusoidal wave by $\pi/2$, a multiplier 815 for modulating the data having passed through roll-off filter 812 by the sinusoidal wave and a multiplier 816 for modulating the data having passed through roll-off filter 813 by the sinusoidal wave rotated in phase by $\pi/2$, and an adder 818 for performing addition of these pieces of modulated data.

In this spread spectrum communication system, the I-phase data D_i and Q-phase data D_q are modulated by Walsh sequences W_0 and W_2 and further processed through complex spreading portion 801 where the signals are subjected to complex spreading modulation using complex number sequences made up of W_0 and W_1 . Further, the output signals are scrambled by a pseudo-random sequence $PN^{(k)}$ uniquely allotted to the user. The signals are then passed through the roll-off filters and

are processed through carrier modulating portion 820, where the signals are carrier-modulated to be output to power amplifier 819. This method has the feature of limiting the phase transition of the signal to reduce the amplitude variation of the signal by performing spread modulation using complex number sequences made up of Walsh sequences.

The method disclosed by Japanese Patent Publication Hei 7 No.312391 is able to improve the characteristic compared to the QPSK spreading modulation, however, the degree of the improvement is not so large and hence is not large enough to meet the conditions required by W-CDMA.

The OCQPSK scheme is able to provide a certain degree of improvement, however, this is not good enough. That is, the reason why the OCQPSK cannot produce high enough improvement is that the Q-phase data D_q is spread modulated by codes represented by W_2 or that the signal is varied in phase by units of 90 degrees every two chips when the signal is input to complex spreading portion 801 shown in Fig.2. Since the restriction on phase transition is effective only when the phase of the symbol does not vary, the effect of restriction on phase transition is limited to one of two transitions, thus sharp improvement of the characteristics cannot be obtained.

It is therefore an object of the present invention to provide a spread spectrum communication system in which the

requirement on the linearity for the amplifier etc. can be alleviated by inhibiting the amplitude variations of the signal more tightly than the above schemes, thus allowing for use of a compact, low-cost and energy saving transmitter.

5

Disclosure of Invention

In order to solve the above problem, the present invention is configured as follows:

10 The first aspect of the invention is a spread spectrum communication system including a transmitter and receiver for performing spread spectrum communications based on a direct sequence spreading scheme and is characterized in that the transmitter includes: a complex spread portion for multiplying an I-phase component signal and a Q-phase

15 component signal of the transmission signal by one type of complex number sequence which will not cause any phase transition of a signal on the I-Q plane in the direction toward the origin; a multiplier for multiplying the signals output from the complex spreading portion by a pseudo-random sequence

20 which is generated at a speed exceeding the symbol rate; a roll-off filter for waveform shaping; and a carrier modulator for performing carrier modulation of the signals having undergone waveform shaping, and that the receiver includes: a carrier demodulator for performing carrier demodulation

25 of the received signal; a multiplier for multiplying the two

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types of signals output from the carrier demodulator by the pseudo-random sequence generated at the same speed as above; a complex despreading portion for performing despreading by multiplying each signal by the complex number sequence; and
5 a phase-correcting portion for performing phase-correction so as to extract the I-phase and Q-phase components.

The second aspect of the invention is the spectrum spread communication system defined in the first aspect and is characterized in that the complex spreading portion includes:
10 a multiplier for multiplying the I-phase component signal and Q-phase component signal of the transmission signal by the complex number sequence; and an adder for performing addition of the I-phase component signal and Q-phase component signal of the transmission signal respectively to the Q-phase
15 component signal and I-phase component signal multiplied by the complex number sequence, and that the complex despreading portion wherein the complex despreading portion performs the despreading includes: a multiplier for multiplying the
20 signals by the complex number sequence; and an adder for performing addition of the signals to the signals multiplied by the complex number sequence, respectively.

The third aspect of the invention is the spectrum spread communication system defined in the first or second aspect, and is characterized in that the complex number sequence is
25 a pattern in which the I-phase component is constantly set

at 1 or -1 and the Q-phase component changes between 1 and -1 alternately.

5 The fourth aspect of the invention is the spectrum spread communication system defined in any of the first through third aspects, and further includes: a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

10 The fifth aspect of the invention is a spread spectrum communication system including a transmitter and receiver for performing spread spectrum communications based on a direct sequence spreading scheme, and is characterized in that the transmitter includes: a permuting processor for permuting the I-phase component signal and the Q-phase component signal of the transmission signal, once every two
15 clock units and at the same time inverting the sign of one of the component signals; a multiplier for multiplying the signals output from the complex spreading portion by a pseudo-random sequence which is generated at a speed exceeding the symbol rate; a roll-off filter for waveform shaping; and
20 a carrier modulator for performing carrier modulation of the signals having undergone waveform shaping, and that the receiver includes: a carrier demodulator for performing carrier demodulation of the received signal; a multiplier for multiplying the two types of signals output from the carrier
25 demodulator by the pseudo-random sequence generated at the

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same speed as above; a permuting processor for permuting the signal multiplied by the pseudo-random sequence, once every two clock units and at the same time inverting the sign of the component signal which underwent sign inversion at the transmitter; and a phase-correcting portion for performing phase-correction so as to extract the I-phase and Q-phase components.

The sixth aspect of the invention is the spectrum spread communication system defined in the fifth aspect, and is characterized in that the permuting processor includes: a multiplier for multiplying one of the component signals of the transmission signal by -1; and a switch which, based on a control signal of 1 and 0 appearing alternately, switches between the combination of the I-phase component signal and Q-phase component signal of the transmission signal and the combination of one component signal multiplied by -1 and the other component signal, and that the permuting inverse processor includes: a multiplier for multiplying the signal which was multiplied by the pseudo-random sequence by -1; a switch which, based on a control signal of 1 and 0 appearing alternately, switches between the combination of the signals which were multiplied by a pseudo-random sequence and the combination between the signal multiplied by -1 and the other signal multiplied by another pseudo-random sequence.

The seventh aspect of the invention is that the spectrum

spread communication system defined in the fifth or sixth aspect, and further includes: a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

5 The eighth aspect of the invention is the spectrum spread communication system defined in the seventh aspect, and is characterized in that the mapping circuit maps each of the signals to the I-phase and Q-phase and independently sets the I-phase or Q-phase amplitude and symbol rate, if required.

10 The ninth aspect of the invention, the spectrum spread communication system defined in the seventh aspect, and is characterized in that the mapping circuit has the mapping function of mapping, when a multiple number of data channels are needed to be allotted in response to an information transfer request arising regularly or eventually, the data onto the I-Q plane by using a multiple number of orthogonal sequences whereby increase in symbol rate due to mapping is minimized.

Brief Description of the Drawings

20 Fig.1 is a block diagram showing a transmitter in a conventional QPSK spread spectrum communication system;

 Fig.2 is a block diagram showing a transmitter in a conventional OCQPSK spread spectrum communication system;

25 Fig.3 is a block diagram showing the first embodiment of a spread spectrum communication system in accordance with

the present invention, (a) and (b) being a transmitter and receiver, respectively;

Fig.4 shows characteristic charts representing time-dependent variations in amplitude of the signals having passed through roll-off filters, (a) for a typical QPSK system, (b) for OCQPSK system and (c) for a system of the first embodiment;

Fig.5 shows characteristic charts representing the cumulative probability distribution of the instantaneous value of the roll-off filter output value, (a) representing the peak value distributions in the above systems and (b) representing the minimum value distributions;

Fig.6 is a block diagram showing the second embodiment of a spread spectrum communication system in accordance with the present invention;

Fig.7 shows illustrative diagrams representing the allocations of the signal points according to the first and second embodiments; and

Fig.8 is a block diagram showing the third embodiment of a spread spectrum communication system in accordance with the present invention.

Best Mode for Carrying Out the Invention

Next, the embodiments of the present invention will be described with reference to the drawings.

<The First Embodiment>

Fig.3 is a block diagram showing the first embodiment of a spread spectrum communication system in accordance with the present invention, Fig.3(a) and Fig.3(b) showing a transmitter and receiver, respectively.

As shown in Fig.3(a), the transmitter is comprised of a complex spreading portion 301 for performing complex spreading modulation of the I-phase and Q-phase data D_i and D_q of a transmission signal, multipliers 306 and 307 for scrambling the data with a pseudo-random sequence $PN^{(k)}$ which is generated at a speed equal to or above some times or some hundreds times of the symbol rate, roll-off filters 308 and 309 for waveform shaping, a carrier modulator 316, a power amplifier 315 and an antenna 317.

Complex spreading portion 301 includes a multiplier 305 for multiplying the I-phase data D_i by a complex number sequence of 1 and -1 appearing alternately, a multiplier 304 for multiplying the Q-phase data D_q by the above complex number sequence, an adder 302 for adding the modulated data through multiplier 304 to the I-phase data D_i and an adder 303 for adding the modulated data through multiplier 305 to the Q-phase data D_q .

The data output from adder 302 is supplied to multiplier 306 and the data from adder 303 is supplied to multiplier 307.

Carrier modulator 316 includes a sinusoidal wave generating circuit 312, a phase-rotation circuit 313 for rotating the sinusoidal wave in phase by $\pi/2$ at the same speed as that at which pseudo-random sequence $PN^{(k)}$ is generated, a multiplier 310 for modulating the data having passed through roll-off filter 308 by the sinusoidal wave and a multiplier 311 for modulating the data having passed through roll-off filter 309 by the sinusoidal wave rotated in phase by $\pi/2$, and an adder 314 for performing addition of these modulated data.

First, the transmission signal is separated into the I-phase component and the Q-phase component, which are input to complex spreading portion 301. In complex spreading portion 301, the data is spread by a complex number sequence pattern of 1 and -1 appearing alternately through multipliers 304 and 305 and adders 302 and 303. Therefore, if no change occurs in data, the signal outputs from complex spreading portion 301 continuously change in phase by ± 90 degrees.

The output from complex spreading portion 301 is modulated by pseudo-random sequences $PN^{(k)}(x)$ allotted to each user through multipliers 306 and 307. Then, the signal is wave-shaped through roll-off filters 308 and 309 so that the baseband signal is modulated by carrier modulator 316, so that the resulting signal is supplied to power amplifier 315, where it is amplified and transmitted from antenna 317.

As shown in Fig.3(b), the receiver is comprised of an antenna 321, a carrier demodulator 322, multipliers 327 and 328 for demodulating the signal with pseudo-random sequence $PN^{(k)}(x)$, a complex despreading portion 329 for performing complex despreading and a phase rotating circuit 334 for performing phase correction based on the reference phase.

Carrier demodulator 322 includes a sinusoidal wave generating circuit 323, a phase rotating circuit 325 for rotating the sinusoidal wave in phase by $\pi/2$, a multiplier 324 for demodulating the received signal through antenna 321 by the sinusoidal wave and a multiplier 326 for demodulating the received signal through antenna 321 by the sinusoidal wave rotated in phase by $\pi/2$.

Multiplier 324 outputs the demodulated signal to multiplier 327.

Multiplier 326 outputs the demodulated signal to multiplier 328.

Complex despreading portion 329 includes a multiplier 333 for multiplying the output signal from multiplier 327 by the complex number sequence, a multiplier 332 for multiplying the signal output from multiplier 328 by the complex number sequence, an adder 330 for adding the output signal from multiplier 332 to the signal output from multiplier 327, an adder 331 for adding the output signal from multiplier 333 to the signal output from multiplier 328 and

integrate-and-dump filters 332 and 333 for performing waveform shaping of the signals received from adders 330 and 331.

On the receiver side, the signal after the demodulation through carrier demodulator 322 is multiplied with x , i.e., pseudo-random sequence $PN^{(k)}$, through multipliers 327 and 328. Then the signal is further despread through complex despread portion 329 and is corrected in phase by phase rotating circuit 334 based on the reference phase information determined using a pilot symbol etc., whereby I-phase and Q-phase information is extracted.

In this spread spectrum communication system, the data is spread using the complex number sequence pattern of 1 and -1 appearing alternately, instead of performing modulation by W_0 and W_2 prior to complex spreading portion 801 shown in Fig. 2, so that the signal output from complex spreading portion 301 will continuously change in phase by ± 90 degrees as long as the data is constant. In this way, the signal input to complex spreading portion 301 is prevented to change at a rate greater than the symbol rate, whereby the effect of phase transition restriction can be enhanced. Thus, phase transition of the spread signal is restricted so as to reduce the amplitude variations of the signal, which makes it possible to alleviate the linearity requirement on the amplifier. An example of the time-dependent variation in amplitude of the signal having passed through the root roll-off filter having

a roll-off factor of 0.22 is shown in Fig.4.

The chart shown in Fig.4(a) represents the characteristic of the amplitude variation of a signal which is spread modulated through a typical QPSK spread system and then passed through the root roll-off filter. In contrast, the Fig.4(b) represents the case using the OCQPSK scheme and Fig.4(c) represents the amplitude variation when the first embodiment is applied. The amplitude variation range of the OCQPSK scheme turned out to be smaller than that of the QPSK scheme. The first embodiment presented a further smaller variation range, proving improvement.

Fig.5 shows the cumulative probability distribution of the instantaneous value of the roll-off filter output value. Fig.5(a) represents the peak value distributions of the above systems and Fig.5(b) represents the minimum value distributions. Since the present embodiment shows the lowest peak value and the largest minimum, it is understood that the amplitude variation range is the smallest compared to the other systems.

<The Second Embodiment>

Fig.6 is a block diagram showing the second embodiment of a spread spectrum communication system in accordance with the present invention. This spread spectrum communication system represents its transmitter, which comprised of a multiplier 401 for multiplying the I-phase data D_i by -1 and

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a switching circuit 402, instead of the complex spreading portion 301 of the first embodiment. Other components are the same as in the first embodiment so the same reference numerals as in the first embodiment are allotted. Switching circuit 402 has switches 403 and 404 controlled in accordance with a control signal.

The transmission signal is separated into the I-phase and Q-phase components and input to switching circuit 402. The I-phase component is processed through multiplier 401 so as to continuously generate its negative-phase signal, which is also supplied to switching circuit 402.

Two switches 403 and 404 in switching circuit 402 are adapted to operate in accordance with a control signal. When a signal which alternately changes between 0 and 1 is supplied as the control signal, the inputs are directly output for even-numbered chips and the inputs D_i and D_q are permuted for odd-numbered chips. For the latter case, the sign of data D_i is inverted by multiplier 401 and input. The output from switching circuit 402 is always shifted in phase by 45 degrees relative that of the first embodiment(see Fig.7). Also in this case, the signal continuously changes in phase by 90 degrees if no change occurs in data, so that the same effect as in the first embodiment can be obtained.

The other operation is the same as the first embodiment. Here, no receiver is shown but the switching circuit is

configured so as to perform reverse operations of the transmitter and the same configuration as in the first embodiment can be employed for the other parts.

5 <The third embodiment>

Fig.8 is a block diagram showing the third embodiment of a spread spectrum communication system in accordance with the present invention, in which a mapping circuit to be disposed prior to the transmitter shown in Fig.3(a) or Fig.6 is shown.

10 In the first and second embodiments, data is allotted for I-phase and Q-phase components as transmission data D_i and D_q . However, for multimedia communications to which W-CDMA is expected to be applied, in order to flexibly deal with various data rates, multi-rate transmission, multi-code transmission and the like are desired.

15 Fig.8 shows a mapping circuit 601 for generating the symbol which is the combination of parallel input data $D^{(0)}$, $D^{(1)}$, $D^{(2)}$, \dots $D^{(N-1)}$ and input to the transmitter in Fig.3(a) or Fig.6.

20 Mapping circuit 601 is configured of multiple multipliers 603 to 604, 606 to 608, \dots , multiple adders 605, 609, \dots , and circuits for generating orthogonal codes C_n . Here, a value 2^1 satisfying the condition $2^{1-1} < [N/2] \leq 2^1$ is determined, where $[x]$ denotes a minimum integer equal to or greater than x .

25 Under this condition, the symbol rate of the output from

mapping circuit 601 becomes equal to 2^1 times of the largest symbol rate of the input to mapping circuit 601. For symbol mapping, arbitrary orthogonal codes can be used. As an example, Walsh-Hadamard sequences can be used. Now, a specific example will be shown. $D^{(0)}$ is assumed as a control channel and $D^{(1)}$, $D^{(2)}$ and $D^{(3)}$ are assumed as data channels. The symbol rate of the control channel is 1/256 of the chip rate and the data channel is 1/32.

In this case, it is assumed that $C_0 = 1, 1$ and $C_1 = 1, -1$, so that the outputs from mapping circuit 601 are obtained as follows:

$$D_i = D^{(0)} \cdot C_0 + D^{(2)} \cdot C_1$$

$$D_q = D^{(1)} \cdot C_0 + D^{(3)} \cdot C_1.$$

For this case, the clock for C_0 and C_1 becomes equal to twice of that of $D^{(1)}$, $D^{(2)}$ and $D^{(3)}$. Thus, one control channel and three data channels can be mapped to generate a symbol having a speed one-sixteenth of the chip rate. This symbol is input to the circuit shown in Fig.3(a) or Fig.6 and is transmitted. In this way, use of such a mapping circuit makes it possible for a single transmitter to send data involving a multiple pieces of information different in transmission rate and in required quality. The information can be demodulated using one or multiple receivers.

According to the present invention, the signals (information symbols arranged at symbol points) arranged on

the I-Q plane are subjected to spectrum spreading using complex number sequences devised so as not to cause phase-transition in a diagonal line direction (toward the origin point), whereby it is possible to reduce the amplitude variation of the signal after roll-off filters and hence narrow the signal dynamic range, which allows a relatively low-cost high efficiency amplifier to satisfy the system specifications as to adjacent channel interface etc. As a result, this invention contributes to reducing the cost of the system and to reducing the power consumption.

Further, use of a mapping circuit makes it possible for a single transmitter to send data involving a multiple pieces of information different in transmission rate and in required quality.

Industrial Applicability

As has been described heretofore, the spread spectrum communication system according to the present invention is applicable to spread spectrum communication systems of a direct sequence spreading type which is used for portable phones, mobile communication systems and the like. Further, the invention contributes to miniaturization, power saving and cost reduction of the transmitter.

CLAIMS

1. A spread spectrum communication system including a transmitter and receiver for performing spread spectrum communications based on a direct sequence spreading scheme,
 5 the transmitter comprising:

a complex spread portion for multiplying an I-phase component signal and a Q-phase component signal of the transmission signal by one type of complex number sequence which will not cause any phase transition of a signal on the
 10 I-Q plane in the direction toward the origin;

a multiplier for multiplying the signals output from the complex spreading portion by a pseudo-random sequence which is generated at a speed exceeding the symbol rate;

a roll-off filter for waveform shaping; and

15 a carrier modulator for performing carrier modulation of the signals having undergone waveform shaping,
 the receiver comprising:

a carrier demodulator for performing carrier demodulation of the received signal;

20 a multiplier for multiplying the two types of signals output from the carrier demodulator by the pseudo-random sequence generated at the same speed as above;

a complex despread portion for performing despread by multiplying each signal by the complex number sequence;
 25 and

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a phase-correcting portion for performing phase-correction so as to extract the I-phase and Q-phase components.

5 2. The spectrum spread communication system according to Claim 1, wherein the complex spreading portion includes:

a multiplier for multiplying the I-phase component signal and Q-phase component signal of the transmission signal by the complex number sequence, and

10 an adder for performing addition of the I-phase component signal and Q-phase component signal of the transmission signal respectively to the Q-phase component signal and I-phase component signal multiplied by the complex number sequence; and

15 the complex despread portion wherein the complex despread portion performs the despread includes:

a multiplier for multiplying the signals by the complex number sequence, and

20 an adder for performing addition of the signals to the signals multiplied by the complex number sequence, respectively.

25 3. The spectrum spread communication system according to Claim 1 or 2, wherein the complex number sequence is a pattern in which the I-phase component is constantly set at 1 or -1

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and the Q-phase component changes between 1 and -1 alternately.

4. The spectrum spread communication system according to any one of Claims 1 through 3, further comprising:

5 a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

10 5. A spread spectrum communication system including a transmitter and receiver for performing spread spectrum communications based on a direct sequence spreading scheme, the transmitter comprising:

15 a permuting processor for permuting the I-phase component signal and the Q-phase component signal of the transmission signal, once every two clock units and at the same time inverting the sign of one of the component signals;

a multiplier for multiplying the signals output from the complex spreading portion by a pseudo-random sequence which is generated at a speed exceeding the symbol rate;

20 a roll-off filter for waveform shaping; and
a carrier modulator for performing carrier modulation of the signals having undergone waveform shaping,
the receiver comprising:

25 a carrier demodulator for performing carrier demodulation of the received signal;

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a multiplier for multiplying the two types of signals output from the carrier demodulator by the pseudo-random sequence generated at the same speed as above;

5 a permuting processor for permuting the I-phase component signal multiplied by the pseudo-random sequence, once every two clock units and at the same time inverting the sign of the component signal which underwent sign inversion at the transmitter; and

10 a phase-correcting portion for performing phase-correction so as to extract the I-phase and Q-phase components.

6. The spectrum spread communication system according to Claim 5, wherein the permuting processor includes:

15 a multiplier for multiplying one of the component signals of the transmission signal by -1; and

a switch which, based on a control signal of 1 and 0 appearing alternately, switches between the combination of the I-phase component signal and Q-phase component signal of the transmission signal and the combination of one component signal multiplied by -1 and the other component signal, the permuting inverse processor includes:

20

a multiplier for multiplying the signal which was multiplied by the pseudo-random sequence by -1;

25 a switch which, based on a control signal of 1 and 0

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appearing alternately, switches between the combination of the signals which were multiplied by a pseudo-random sequence and the combination between the signal multiplied by -1 and the other signal multiplied by another pseudo-random sequence.

5

7. The spectrum spread communication system according to Claim 5 or 6, further comprising:

a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

10

8. The spectrum spread communication system according to Claim 7, wherein the mapping circuit maps each of the signals to the I-phase and Q-phase and independently sets the I-phase or Q-phase amplitude and symbol rate, if required.

15

9. The spectrum spread communication system according to Claim 7, wherein the mapping circuit has the mapping function of mapping, when a multiple number of data channels are needed to be allotted in response to an information transfer request arising regularly or eventually, the data onto the I-Q plane by using a multiple number of orthogonal sequences whereby increase in symbol rate due to mapping is minimized.

20

25

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ABSTRACT

A spread spectrum communication system is to control the signal amplitude variation so as to alleviate the requirement of the linearity on the amplifier etc., thus allowing for use of a compact, low cost and energy saving transmitter.

The transmission signal is separated into the I-phase component and the Q-phase component. In a complex spreading portion(301), spreading is performed by using multipliers (304 and 305) and adders (302 and 303) together with a sequence pattern of 1 and -1 appearing alternately. The outputs from the complex spreading portion (301) are modulated in multipliers(306 and 307) using pseudo-random sequences $PN^{(k)}(x)$ allotted for individual users. The baseband signal which underwent waveform shaping by roll-off filters(308 and 309) is modulated through a carrier modulator(316), then sent to a power amplifier(315), where it is amplified and transmitted via antenna(317).

FIG. 1

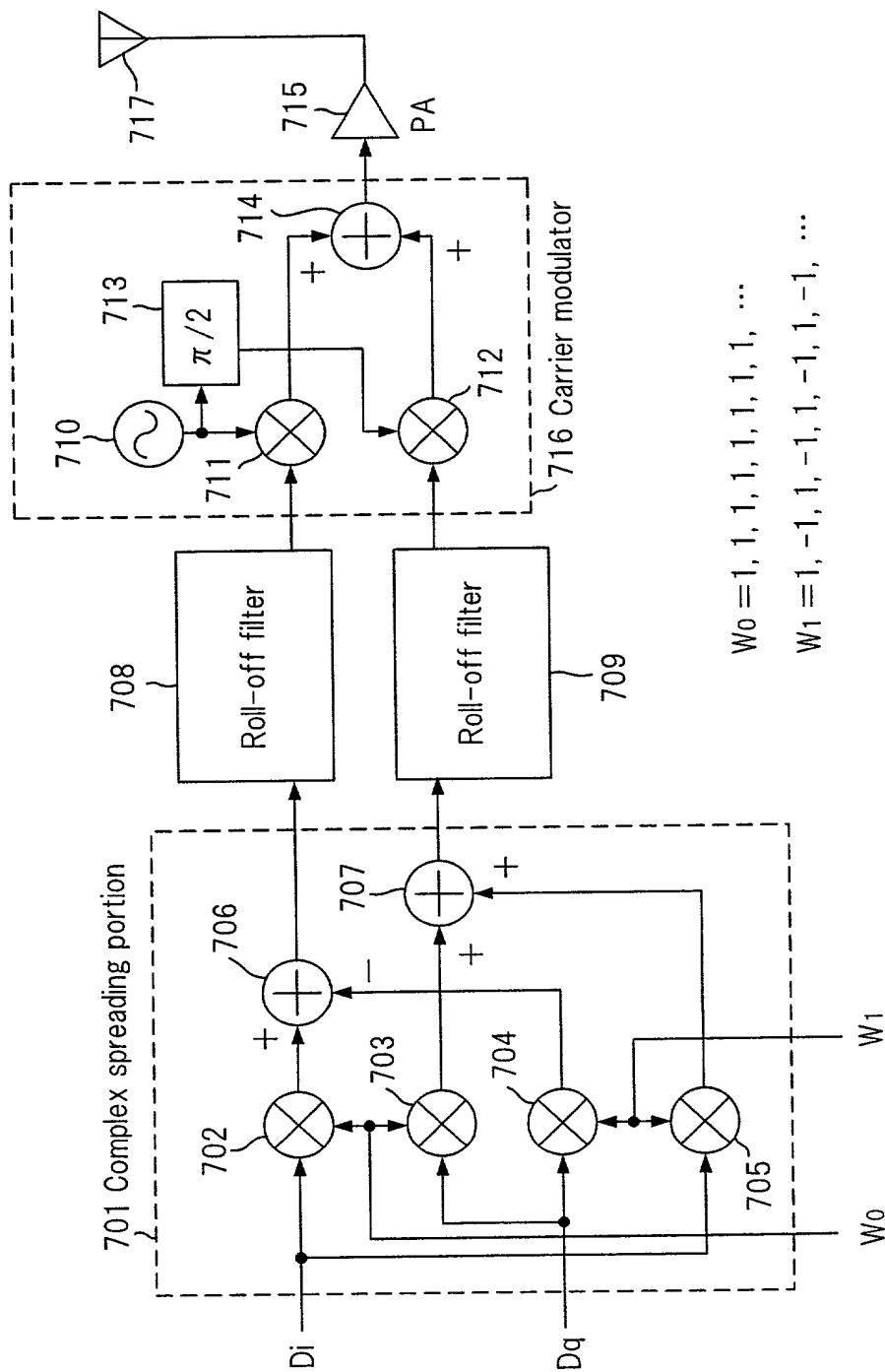
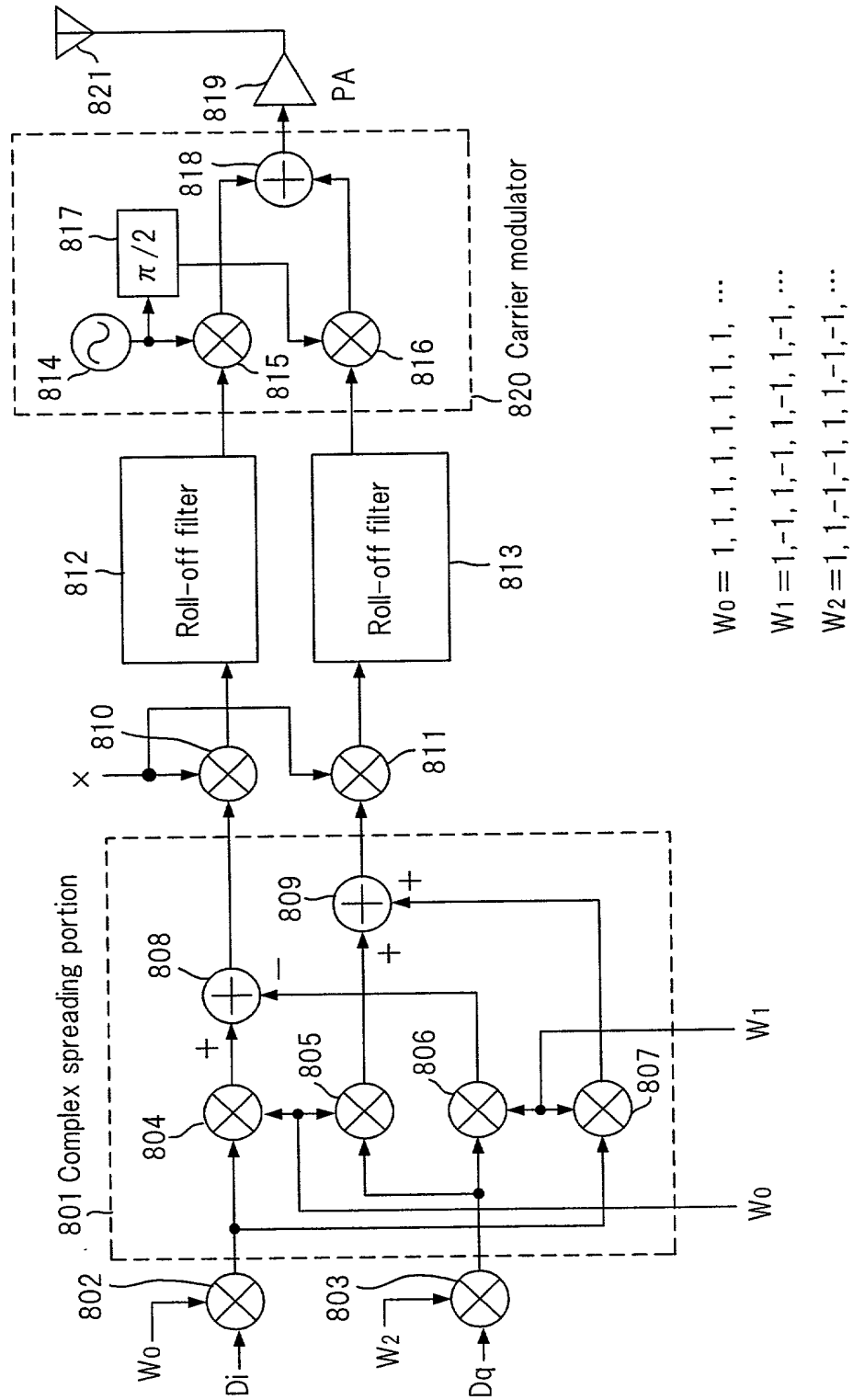
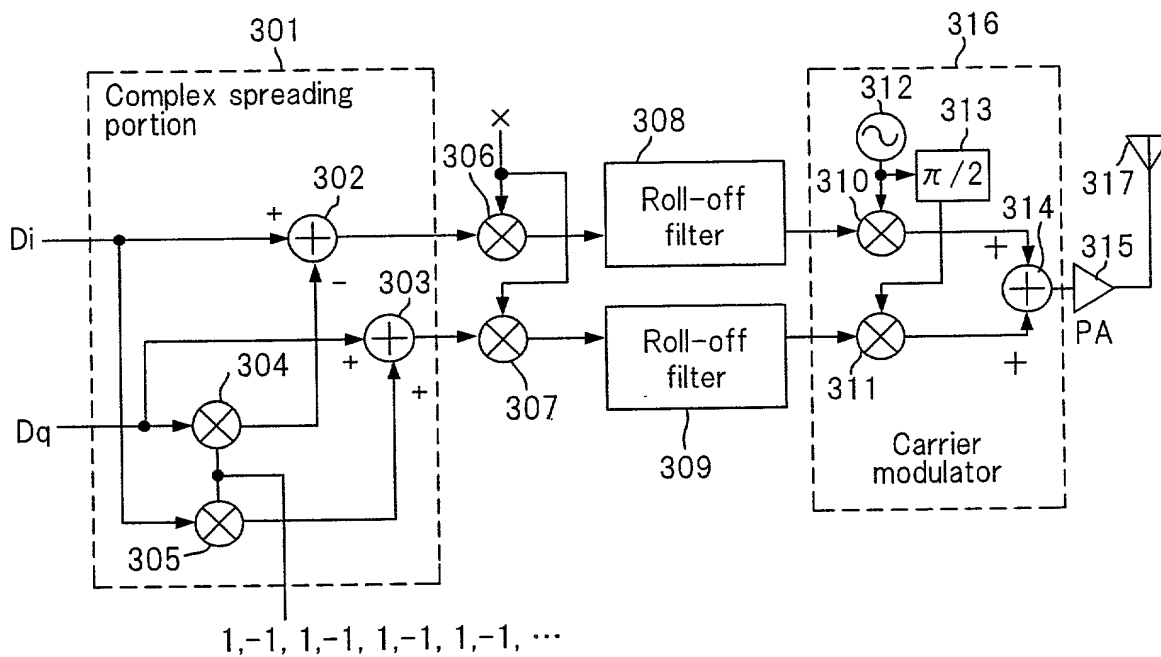


FIG. 2

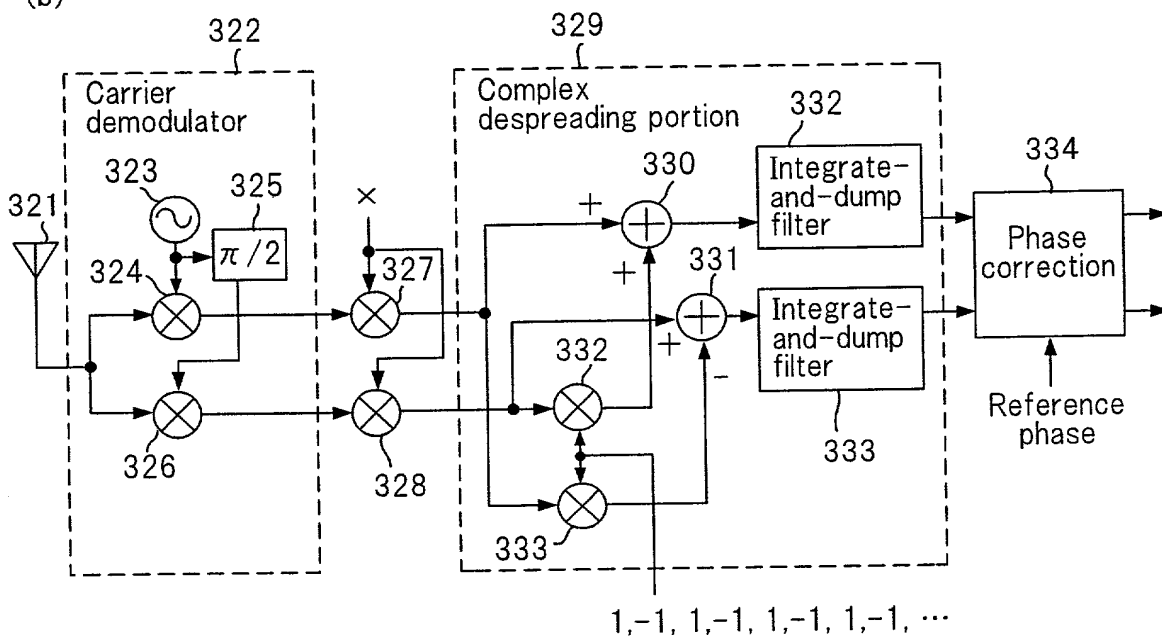


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FIG. 3

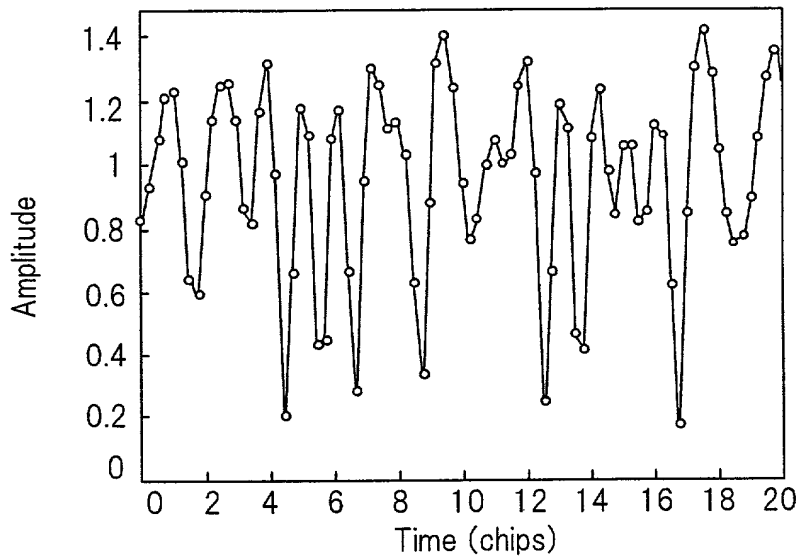
(a)



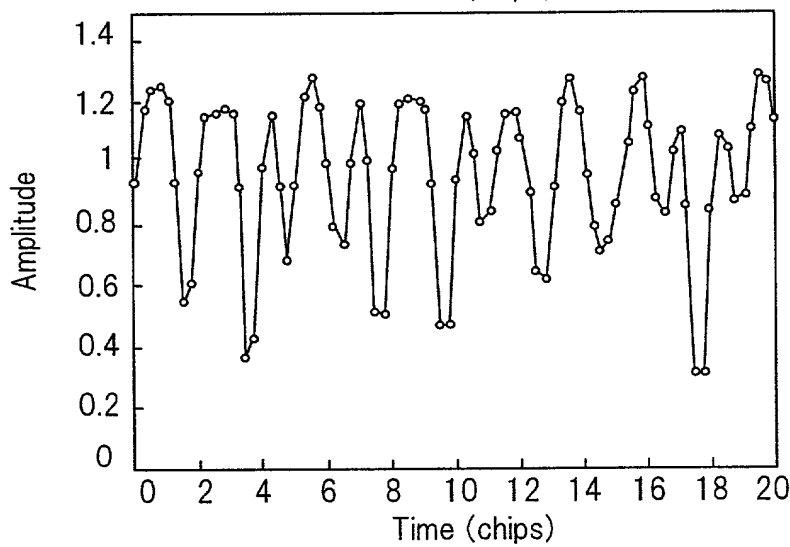
(b)



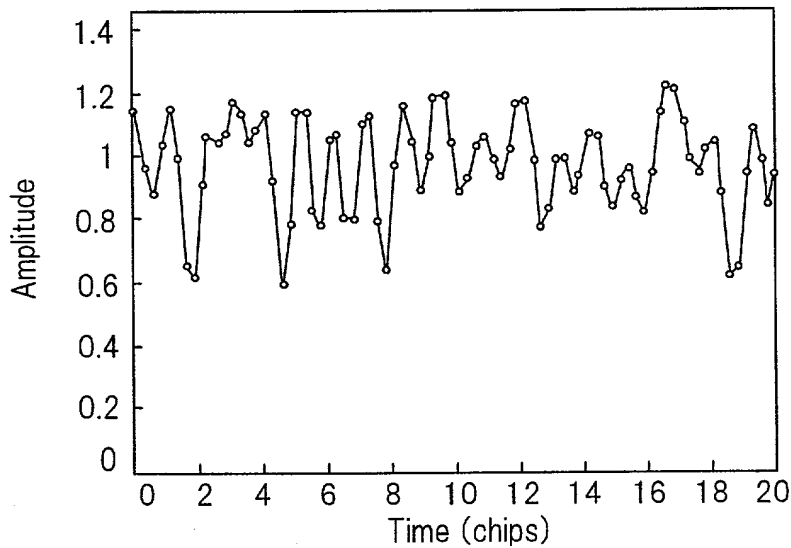
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FIG. 4

(a) In the case of
QPSK spreading



(b) In the case of
OCQPSK spreading



(c) In the case of the
first embodiment

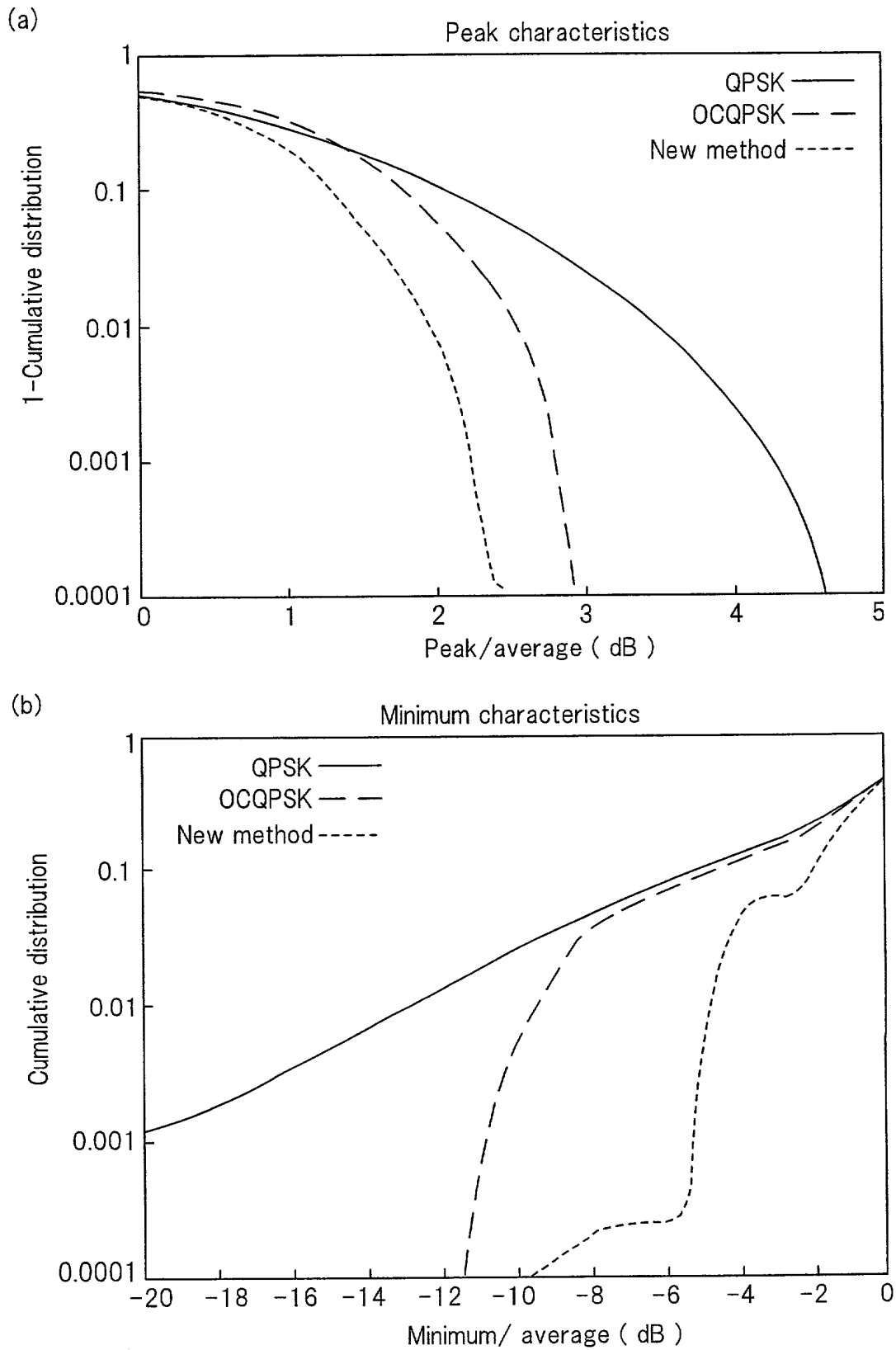
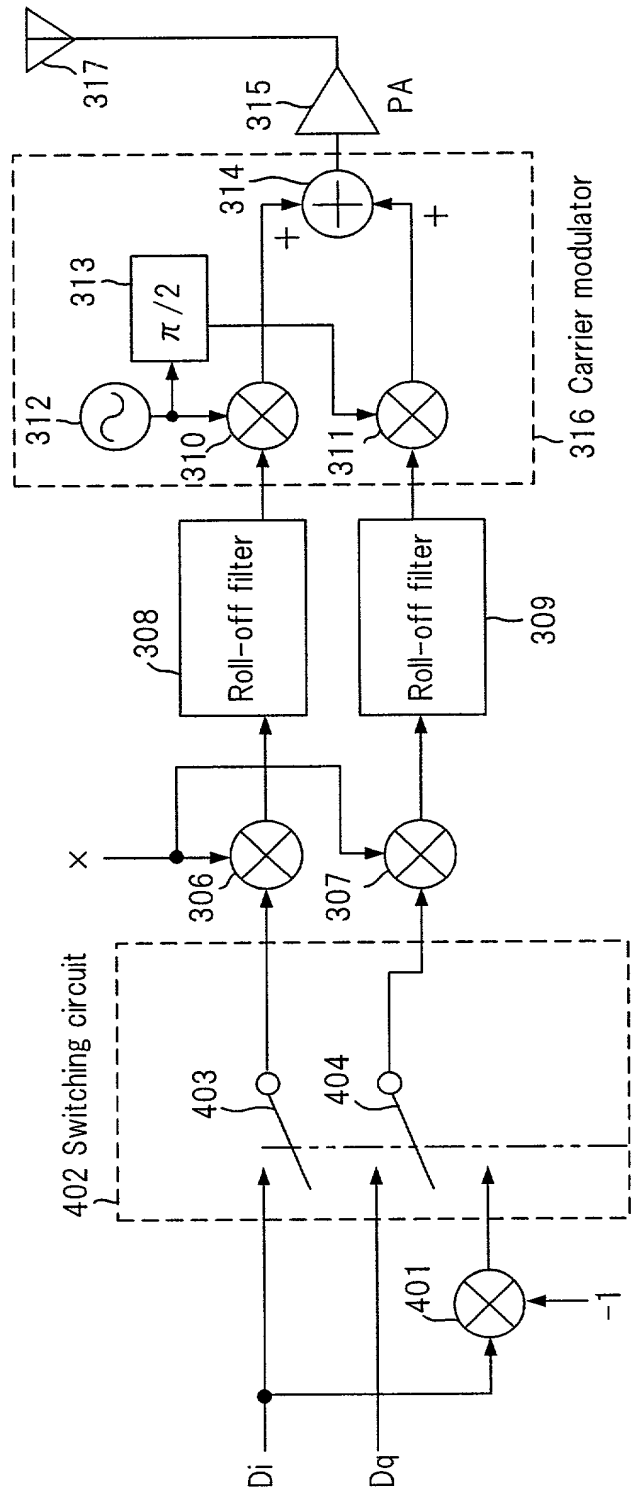
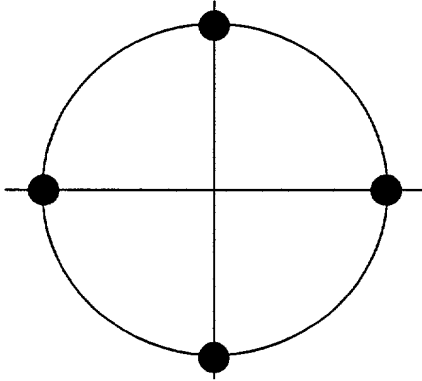
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FIG.5

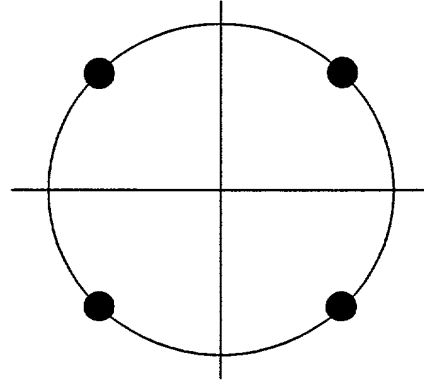
FIG. 6



1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0 ...

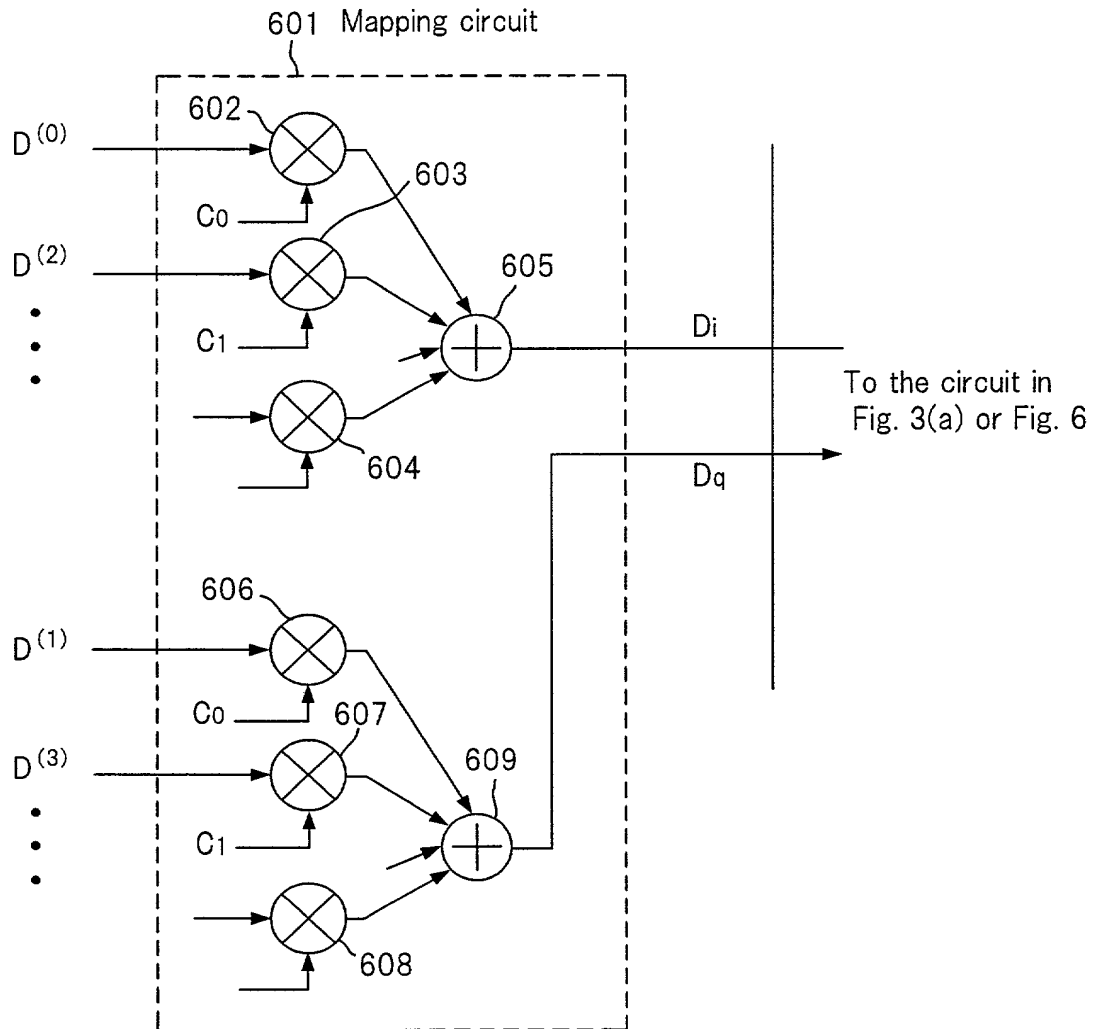
FIG. 7

Signal points in the
first embodiment



Signal points in the
second embodiment

FIG. 8



FOR ADDITIONAL INVENTORS, check box ☐ and attach sheet with same information and signature and date for each.